

2008 SAE Alternate Refrigerant System Symposium
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Greenhouse Gas Emissions and Abatement Opportunities in Do-it-Yourself Recharging of Leaky Motor Vehicle Air Conditioning Systems in California



Tao Zhan, John Collins, Tao Huai, Winston Potts, Dorothy Shimer, Pablo Cicero-Fernandez, and Alberto Ayala

California Air Resources Board

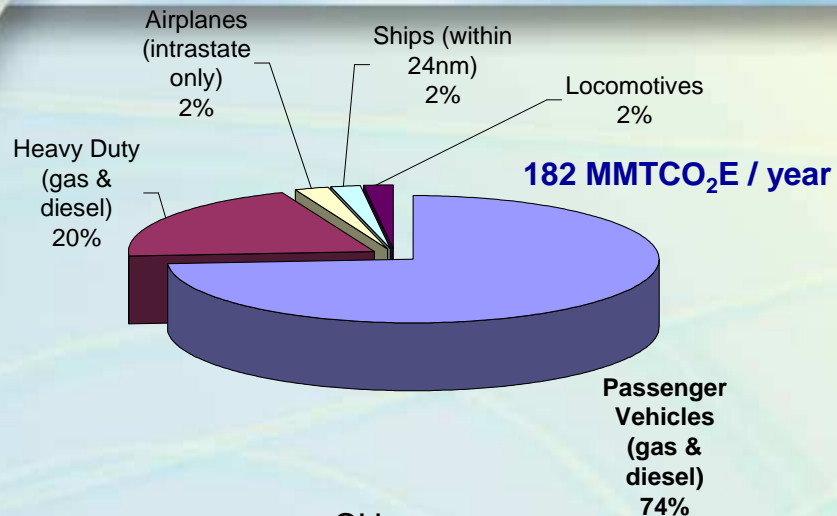


Lionel Palandre, Yousef Riachi, Arnaud Tremoulet, and Denis Clodic

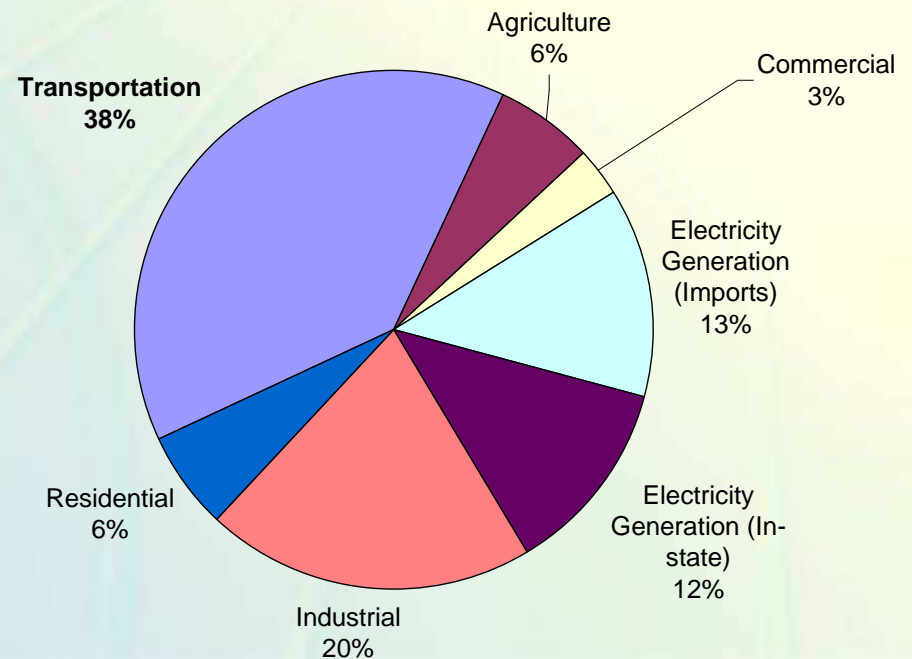
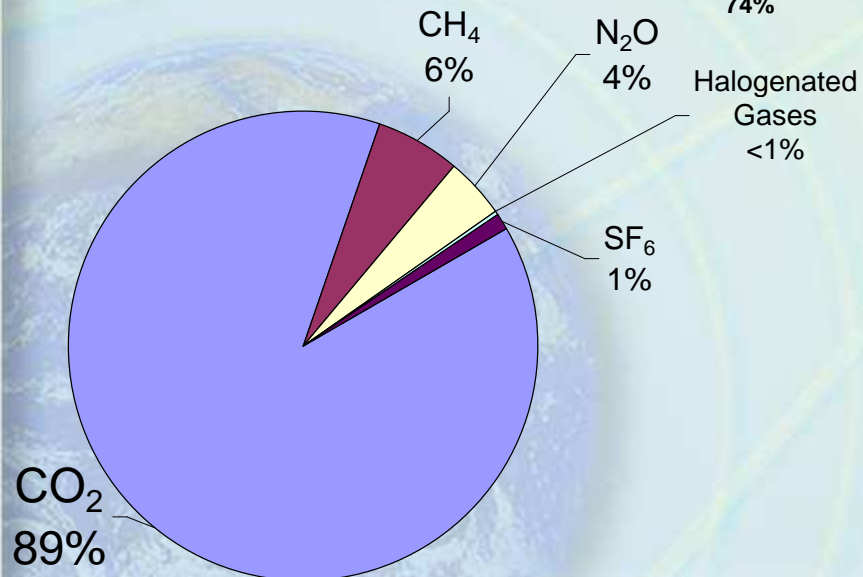
**Center for Energy and Processes
Paris School of Mines**



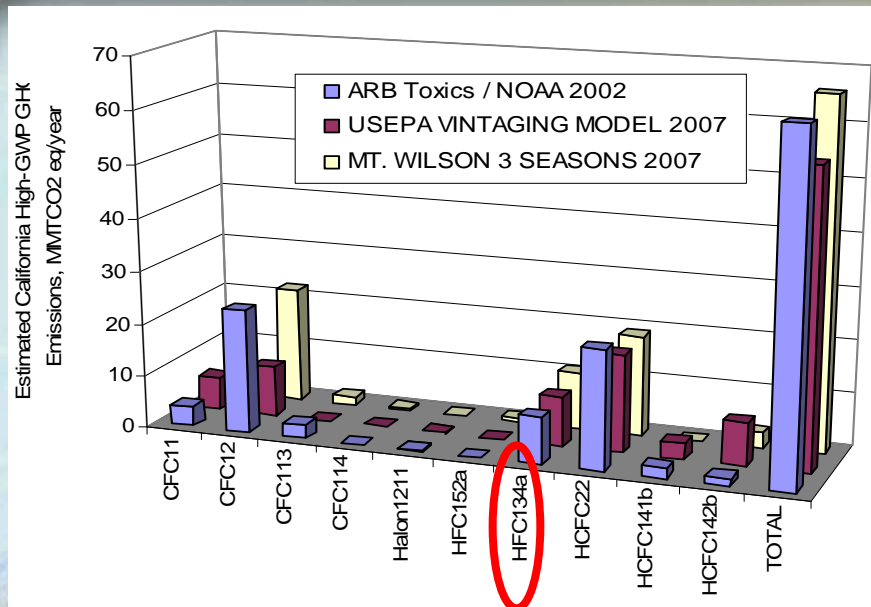
California GHG Emissions (480 MMTCO₂E, 2004)



Key interest:
High GWP refrigerants used in transportation, commercial, and residential applications



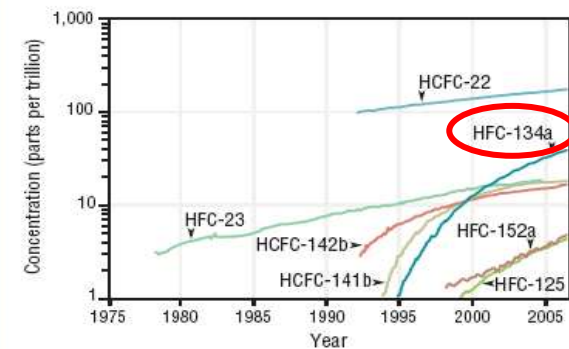
HFCs Emissions & Ambient Concentrations Growing Rapidly



Estimated CA HFC-134a Emissions from Mobile Sources Based on USEPA Vintaging Model Estimates (MMTCO₂E/yr)

2006	2020	2030
9	12	15

Exhibit 2-55. Global atmospheric concentrations of selected halocarbons, 1978-2006^a



^aTrends are presented for hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) with sufficient data to support long-term trend analysis.

Data source: IPCC, 2007

Source: U.S. EPA. EPA's 2008 Report on the Environment (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-07/045F.

Mobile HFCs are almost 60% of total HFC emissions in California*

*U.S. EPA's Vintaging Model, 2005

California Climate Protection Plan:

Cradle-to-Grave Suite of Measures for HFC-134a Emission Reductions

New vehicles

Pavley Regulation
(AB1493) for LDVs

HDVs and off-
road fleet

Cool Cars (paints and
glazing for vehicles <
10,000lbs)

New motor vehicle
GHG labeling
regulation
(using SAEJ2727 &
SAEJ2766)

Pavley II Regulation (GWP
limit, OBD, etc)

In-Use Fleet

*DIY small
can*

I/M Smog Check
leak check

New
requirements for
professional
servicing

New leaky
MVACS "fix it
requirement"

Commercial
Refrigeration
Specification
Program

End-of-Life

EOL refrigerant
reclaiming/recycling

Refrigerated
shipping
containers

DIY Recharging Using HFC-134a

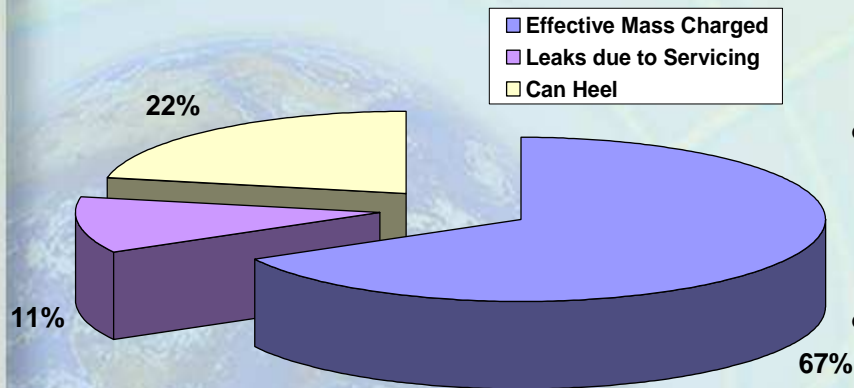
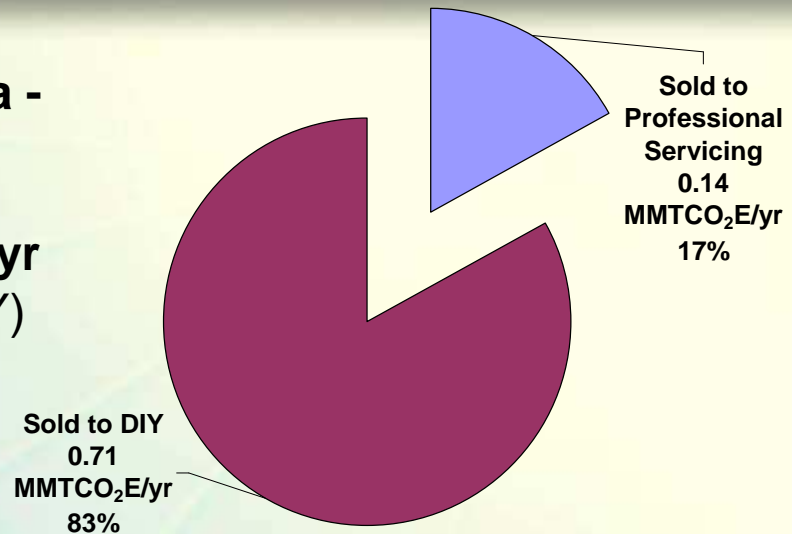
- Do-it-Yourselfers (DIY) recharge MVAC by adding HFC-134a from small cans, incurring emissions in various ways
- AB 32 Discrete Early Action Plan* –
 - regulation required by 1/1/2010
 - under California's Global Warming Solutions Act of 2006 (AB 32)
- CARB commissions research by CEP/Paris School of Mines**
- French field team deployed in California (Northern and Southern)

* http://www.arb.ca.gov/cc/ccea/meetings/ea_final_report.pdf

** http://www.arb.ca.gov/cc/hfc-mac/documents/IntermediateReport_SmallCans_011008.pdf

Business as Usual DIY Emissions Apportionment

- 2 million cans/yr sold in California - 0.85 MMTCO₂E/yr*
- Total Emissions - 0.71 MMTCO₂E/yr (HFC-134a sold in small cans to DIY)

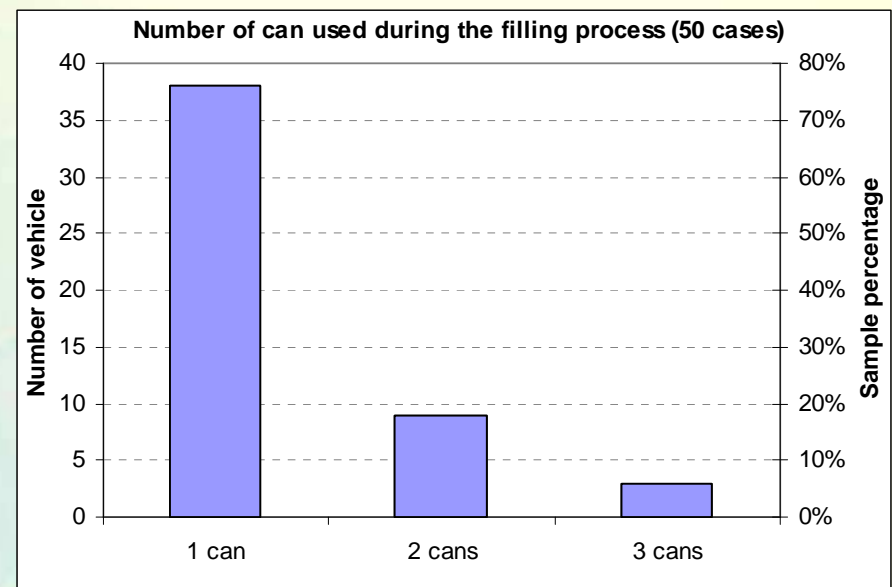


- Immediate Emissions (0.23 MMTCO₂E/yr)
 - 0.15 MMTCO₂E/yr
 - 0.08 MMTCO₂E/yr
- Delayed Emissions (0.48 MMTCO₂E/yr)
 - 67% charged to vehicle
 - Eventually leaks out since there is usually no repair

* CARB's consumer product survey 2006

Profile of the Nominal California DIYer

- 1.2 million DIY operations^{1,3}
- 18% DIY consumers are low income²
- 25% of DIY leak 60% of immediate emissions³
- No A/C servicing for the first 7 years⁴
- Recharge A/C once per year³
- Average vehicle lifetime in California is 16 years⁵



Sources:

1. ARB Consumer Product Survey for 2006
2. Frost and Sullivan Study
3. ARB Sponsored Study on DIY (PI: Denis Clodic)
4. I-MAC Study
- 5- Pavley (AB1493) regulation

Emission Abatement Opportunities

- **CARB original proposal**
 - Ban retail sales of HFC-134a in small cans
 - Similar to State of Wisconsin (1992)
 - In concert with Europe's F-gas Directive (2007)
- **Industry proposal**
 - Self-sealing valves on cans
 - Voluntary deposit and recycling program
 - Improved labeling on cans

Emission Abatement Opportunities (cont'd)

- **Alternative regulatory approach – *first reduce, then offset***
- **DIY practice reductions:**
 - Requirement for self-sealing valves
 - Requirement for enhanced recycling program
 - mandatory targets
 - increased deposit incentive at set intervals until target recycling rate is met
 - Meaningful consumer education program
 - Additional rulemakings for professional A/C servicing
 - Additional rulemakings for leaky MVACSs “fix it” requirement
- **Carbon mitigation fee:**
 - First, achieve maximum feasible emission reductions that are cost-effective
 - Then, mitigate climate impact of remaining uncontrolled emissions
 - Can be directed to mitigation projects within or outside the sector
 - Can be an alternative or a supplement

Preliminary Benefit Analysis

Mitigation Approach	Remaining Emissions MMTCO ₂ E/yr	Emission reduction potential (MMTCO ₂ E/yr)
BAU	0.71	NA
Can Ban	0.24	0.47
Industry Proposal	0.52	0.19
Alternative Approach	0.29	0.42
Carbon Mitigation Fee	---	Up to 0.85

Closing remarks

- California's Climate Protection Plan kicked off for HFCs
- Key interest: HFC for mobile applications
- Emissions due servicing of MVACSs by DIYer are completely unnecessary
- Prompt control of required under AB 32 Discrete Early Action Plan
- No decision yet. Multiple options for effective control exist
 - Ban is possible
 - Other options also effective: better cans, deposit & return program, meaningful consumer education
- Rule making for small cans by 1/1/2009
- Additional rulemakings needed for professional A/C servicing and leaky MVACSs
- Other measures to follow seeking superior MVACSs with best lifecycle climate performance

What will the cans contain in 20 yrs?

- HFO-1234yf (GWP<5) is a leading contender
- CO₂ is a reality
- HFC-152a (GWP=120) still in the running
- others?

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Ranking of Refrigerants

GUILLERMO RESTREPO,^{†,‡}
MONIKA WECKERT,[†]
RAINER BRÜGGEMANN,[§]
SILKE GERSTMANN,[†] AND
HARTMUT FRANK^{*,†}

Environmental Chemistry and Ecotoxicology, University of Bayreuth, Bayreuth, Germany, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany, and Laboratorio de Química Teórica, Universidad de Pamplona, Pamplona, Colombia

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Environmental ranking of refrigerants is of need in many instances. The aim is to assess the relative environmental hazard posed by 40 refrigerants, including those used in the past, those presently used, and some proposed substitutes. Ranking is based upon ozone depletion potential, global warming potential, and atmospheric lifetime and is achieved by applying the Hasse diagram technique, a mathematical method that allows us to assess order relationships of chemicals. The refrigerants are divided into 13 classes, of which the chlorofluorocarbons, hydrofluorocarbons, hydrochlorofluorocarbons, hydrofluoroethers, and hydrocarbons contain the largest number of single substances. The dominance degree, a method for measuring order relationships among classes, is discussed and applied to the 13 refrigerant classes. The results show that some hydrofluoroethers are as problematic as the hydrofluorocarbons. Hydrocarbons and ammonia are the least problematic refrigerants with respect to the three environmental properties.

From an environmental perspective, the selection of a suitable refrigerant must be made because there is no one solution at the same time. It must be selected by simultaneously considering and ranking them according to several factors. This can be achieved as follows.

Materials and Methods. In a ranking, the objects q_1, \dots, q_n are used in a set G . For example, f, g may be descriptors in Figure 1. A linear order q_i is considered; for q_i is regarded, and descriptor q_2 of a is one of e is equal to t is equivalent in the and q_2 are environmental with the extent of a the "most hazardous". In real cases, the several descriptors, simultaneously. Many combinations of descriptors. For instance, the use of each object x , giving to eq 1.

If equal priorities can be depicted in descriptors are similar weights is still subjective. The method is the following.